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THE MACCHIE OF THE NEAPOLITAN COAST REGION.

J. Y. Bergen.

(*Continued from p. 362.*)

CLIMATIC ENVIRONMENT. ADAPTATIONS TO CONDITIONS.

The general character of the Neapolitan climate, with its mild moist winters and long dry summers, has been mentioned in a previous article. The irregular distribution of the mountains along the coast of the Bay of Naples and upon its islands produces considerable inequalities in the rainfall of localities not widely separated.

In Capri, during the summer in which I was engaged in studying its flora (1902), the precipitation was less than usual, 45^{mm} in May, ending on the twentieth, and then a rainless period of four months, except for a shower of 6^{mm} on September 13. During a more nearly average year (1901) the precipitation for May was 179^{mm}, June and July 56.5^{mm}, August none, and September 97.2^{mm}.

During the three hot, dry months (June, July, August) the nights are usually moderately cool. In 1902 the minimum for the three months was 10.8° C. The maximum for the same period, measured under strictly standard conditions, was 31.9° C. The average of daily maximum temperatures for June, July, and August was 26.4° C. It is noteworthy that the heat is continuous, the maximum of each day usually differing less than 2° from that of the day before or the following day. The desiccating effect of hot air upon vegetation is, of course, largely dependent upon the relative humidity of the atmosphere. During June, July, and August, 1902, the relative humidity at 3 P. M. never exceeded 81 and not infrequently fell to 30 or less; once as low as 27. The average relative humidity at 3 P. M., for the three months in question, was 55. The average velocity of the wind in summer at 3 P. M. was about 9^{km} per hour.

It should be remembered in discussing the conditions of existence of plants during hot and dry periods that they are often exposed to the full heat of the sun, and therefore to a very different temperature from the recorded maximum of a meteorological observatory. Observations on the northwestern slope of Monte Solaro, Capri, at about 350^{m} above sea level gave a temperature in the shade August 20 of 31.6° C., at 2 P. M. Burying the bulb of the thermometer a centimeter or two in the soil, in full sunshine, gave a temperature of 50.5°, and placing the bulb of the instrument on the surface of the ground and covering it with dry grass, to exclude the direct rays of the sun, gave a reading of 52.2°. Other days during the same month gave a temperature, as recorded at the neighboring observatory, over three degrees higher than that of August 20, so that the surface temperature, in sunshine, must have been at times as high as 55° C., with a relative humidity as low as 29. This extreme heat is sufficient to demand elaborate protection to prevent excessive transpiration; it approaches the temperature (50° to 60°) of desert soil at midday in summer reported by Volkens.[3] Examination near the locality above mentioned showed during early September an entire lack of sensible moisture, *i. e.*, moisture evident to the eye or the touch, to a depth of from 1 to 2^{m}.

Some data in regard to temperature and rainfall, as recorded at the Royal Observatory of Capodimonte, Naples, are given in the little table subjoined. It is noticeable that the mean of

1902	Mean value of maximum daily temperatures (° C.)	Mean values of minimum daily temperatures (° C.)	Mean value of daily humidity at 3 P. M. (per cent.)	Total rainfall (millimeters)	Means of maximum daily temperatures for thirty-five years (° C.)	Mean rainfall for thirty-five years (millimeters)
May	18.35	11.42	55.3	80.2	21.70	53.42
June	23.99	16.59	55.0	8.0	25.41	31.64
July	28.73	20.50	53.8	0.0	28.53	19.12
August	28.66	20.29	53.8	9.0	28.34	23.88

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[3] GEORGE VOLKENS, Flora der ægyptisch-arabischen Wüste 23. Berlin, 1887.

maxima of daily temperatures is a little higher, the mean daily humidity a trifle lower, and the rainfall notably more than at Capri. On the mainland in general the temperatures would run somewhat higher and the humidity lower than at Capodimonte.

The total rainfall for the year at Capodimonte (average of 35 years) is 865.5$^{\mathrm{mm}}$. In an average winter there are only two days in which the temperature falls below 0° C.

The plants which constitute the macchie of the territory under discussion show their xerophytic character more by their mechanisms for the prevention of transpiration than by their provisions for absorbing water or for storing it in large quantities. The most notable succulent plants found in the Neapolitan region are two introduced species, *Agave americana* L., and *Opuntia Ficus-indica* Mill., neither of which occurs as a member of the plant societies here treated. The root systems of most of the plants which constitute macchie are extensive and in the case of many of the species examined by the writer contained more tissue than the stems. The most notably developed roots examined were those of *Daphne Gnidium*. This occurs as an undershrub, with slender clustered stems, usually less than a meter in height. In one specimen examined the average height of the stems was 70$^{\mathrm{cm}}$ and the total length of the tap root and its immediate branches was 490$^{\mathrm{cm}}$, with a diameter at the crown of 7$^{\mathrm{cm}}$. The leafy stems together weighed 190$^{\mathrm{gm}}$, while the root system (not quite all secured) weighed 3,030$^{\mathrm{gm}}$. The roots evidently contained much water, and this accounts for the fact that the Daphne, after four months of rainless, hot weather, showed perhaps less signs of distress than any other member of the plant society to which it belonged except Thymelaea.

It has seemed to the writer best worth while to devote his attention mainly to the discussion of the various hindrances to transpiration which present themselves in the most evidently well-equipped of the xerophytic shrubs and undershrubs already enumerated. These adaptations may perhaps best be exhibited in some such table as the following:

MEANS OF PROTECTION AGAINST EXCESSIVE TRANSPIRATION.

	Leaflessness	Leaves (or cladodes) more or less vertical	Acicular or subulate leaves	Minute leaves	Leaves deciduous in summer	Leaves rolling up or withering	Leaves permanently concave, revolute or sulcate	Leaves with glossy epidermis	Leaves coriaceous	Leaves hairy or sericeous	Leaves aromatic	Leaves varnished	Stomata sunken in pits or furrows	Epidermal cells liquefied	Containing stored water or mucilage	Upper epidermis destitute of stomata
1. Ruscus aculeatus L. . . .	×	×											×		×	
2. Asparagus acutifolius L.	×												×			
3. Pinus halepensis Mill. .			×											×		
4. Erica arborea L.			×													
5. Ulex europaeus L.			×													
6. Euphorbia dendroides L					×											×
7. Euphorbia spinosa L. . .				×												
8. Thymelaea hirsuta Endl.		×		×			×	×	×	×					×	
9. Calycotome villosa Link.					×					×						×
10. Spartium junceum L. . .				×	×								×			
11. Anthyllis Barba-Jovis L.				×			×			×						×
12. Coronilla Emerus L. . .					×											×
13. Cistus villosus L.					×	×				×						
14. Cistus salvifolius L. . . .					×	×				×						×
15. Cistus monspeliensis L. .							×				×	×				
16. Inula viscosa Ait.						×					×	×				
17. Myrtus communis L. . .								×	×		×					×
18. Rosmarinus officinalis L.							×		×	×	×					×
19. Daphne Gnidium L. . . .		×						×	×							×
20. Pistacia Lentiscus L. . .								×	×							×
21. Arbutus Unedo L.								×	×						×	×
22. Smilax aspera L.								×	×							×
23. Rhamnus Alaternus L. .								×	×							×
24. Lonicera implexa Ait. . .								×	×							
25. Ceratonia Siliqua L. . .								×	×						×	
26. Phillyrea variabilis Timb. & Lor.									×							
27. Quercus Ilex L.									×	×				×		×
28. Quercus Aegilops L. . .									×	×						×
29. Quercus Cerris L.									×	×						
30. Quercus pubescens Willd.									×	×						×
31. Clematis Flammula L. .										×						×
32. Cytisus spinescens. . . . . Sieb. var. ramosissimus Ten.				×						×						×
33. Cytisus triflorus L'Her. .										×						
34. Cytisus monspessulanus L.										×						
35. Cystisus hirsutus L. . . .										×						
36. Rubus discolor W. & N.										×						×

The characteristics which belong to each species are checked in the horizontal line on which the name of the species occurs.

It is evident at a glance that a majority of these plants have more than one adaptation each to prevent too rapid transpiration. *Thymelaea hirsuta*, which is protected in the greatest number of ways, is notable as being equally at home on parched mountain sides and in the somewhat saline, almost waterless, sands of Mediterranean beaches, above the reach of ordinary waves. Six species are set down as deciduous in summer, but they are not all equally so. The most notable of these are *Spartium junceum* and *Euphorbia dendroides*. The former generally loses all its leaves early in the dry season and does not usually acquire new ones until the following February, while the *Euphorbia*, when in fairly good soil, retains all, or nearly all, of its immense number of leaves (much like those of *E. Cyparissias* L. of the northeastern United States, only on a larger scale). But in the scantiest soil, or when found growing in the crevices of sunny cliffs, *E. dendroides* appears in summer as a rather succulent, absolutely leafless, much-branched undershrub of a meter or less in height. The economy in transpiration, due to the leafless summer condition of the plant, may be appreciated from the results of a rough experiment. A leafy twig, cut on August 29, 8^{cm} long, bore 86 leaves, of an area varying from $9^{sq\ cm}$ each for the older leaves to about $0.25^{sq\ cm}$ each for the youngest ones. The cut end of this twig was sealed with grafting wax, the cut end of a leafless twig was similarly sealed, then both were weighed and left for 48^{hrs} freely exposed to the air and sunshine. On reweighing, the leafless twig was found to have lost 5 per cent. of its weight and the leafy one 23 per cent.

The large number of plants in these macchie which owe their tolerance of extreme drought to a glossy reflecting leaf epidermis (and usually also to the coriaceous texture of the leaves) is a noteworthy fact. Various species of the same genus are often protected against excessive transpiration in very different degrees. For instance *Quercus Ilex*, *Q. Aegilops*, *Q. Cerris*, and *Q. pubescens* constitute a series of decreasingly xerophytic character. The first has small, extremely coriaceous leaves, with a felt-like pubescence beneath; the second has larger leaves, which are very coriaceous, and beneath are stellate hairy; the third has larger leaves which are less coriaceous and only moderately pubescent, while the fourth has leaves equally coriaceous with those of *Q. Cerris*, but hardly at all pubescent except when young.

As is often the case in other plant societies, some genera of the macchie show various modes of adaptation to their conditions of life in the several species which represent them. For instance, *Euphorbia dendroides* is protected from dessication mainly by its summer-deciduous habit, while *E. spinosa* is rendered secure by the meagerness of its foliage and the spiny character of its densely clustered branches. *Cistus villosus* and *C. salvifolius* have pubescent leaves, which roll up somewhat or even wither or fall during the season of extreme drought, while the narrow, revolute-margined, somewhat aromatic, viscid leaves of *C. monspeliensis* suffer little or no change even in the driest weather.

The species numbered 20–28 in the preceding table are (with the exception of no. 24) typical members of the sclerophyll society which Schimper describes[4] as the Mediterranean *Hartlaubflora*. As broad-leaved evergreens, they form a conspicuous feature of every wooded landscape, and the dark green color and glossy surface of the leaves of such shrubs and trees as the Pistacia, the Arbutus, the Rhamnus, and the Ceratonia make them highly ornamental. The coriaceous quality of these leaves is of service, as pointed out by Beck (*op. cit.*, p. 116) in withstanding the severe lashings which they undergo from the frequent winter rain and wind storms of the Mediterranean coast, and, as suggested by Kerner in his *Oesterreich-Ungarns Pflanzenwelt* 190, in enduring occasional frosts. In this latter respect some species are not much inferior to the evergreen species of Rhododendron of the eastern United States.

It has been impossible for the writer to secure suitable laboratory facilities for the detailed study of the leaves of the trees and shrubs discussed in the present paper, at times when he could avail himself of them. Many species have been fully investigated by competent hands, but others which have not will repay thorough study. Only a few notes are here offered.

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[4] Pflanzengeographie. Jena 1898. Pp. 547–55.

Most of the evergreen sclerophyll species examined have a thick, apparently structureless cutinized layer overlying the cells of the upper epidermis. In *Rosmarinus officinalis*, *Pistacia Lentiscus*, *Smilax aspera*, and *Quercus Ilex*, this layer is especially well developed. In the species of the macchie generally the upper epidermis is destitute of stomata. Those checked as thus characterized in the table (p. 419) do not by any means exhaust the list, since the leaves of many species were not readily available to the writer for examination. *Olea europea*, *Colutea arborescens*, and *Viburnum Tinus*, occasional members of the Neapolitan macchie, are all destitute of stomata in the upper epidermis. On the other hand, *Inula viscosa* has many, but its leaves wither in the hottest weather, and they are somewhat protected by a varnish-like covering. *Spartium junceum* also possesses very small stomata in the epidermis of the upper surface of the leaf, but the leaves are few in number, small, and deciduous in summer. *Convolvulus Cneorum*, an undershrub of rare or local occurrence, has many stomata in the upper leaf surface, but these are protected by a dense layer of closely appressed long silky hairs. The case of *Thymelaea hirsuta* is particularly interesting. It has already been mentioned as an extremely xerophilous plant, and the histology of its leaves throws much light on its power to regulate transpiration. The leaves are numerous, about 5^{mm} long by 3^{mm} wide, somewhat appressed to the branchlets, with the outer surface smooth and shining, the inner surface concave and densely covered with a short, kinky, white pubescence. The branches droop, so that the outer leaf surfaces, which are morphologically the lower or distal ones, are geocentrically the upper surfaces. These contain no stomata, but the concave, pubescent inner surfaces are provided with stomata. The outer epidermis is covered with a cuticular layer, lined with hemispherical cells of a pale yellowish color, apparently containing water stored in the form of a thin mucilage. The next layer is of larger cells, which appear to contain nearly pure water. The mesophyll, which constitutes the main bulk of the leaf, is loose, with no well-differentiated layers of tissue.

Perhaps it would not be easy to sum up the characteristics of the histology of the leaves of most of the species which constitute the macchie better than by referring to a paper by W. Russell.[5] He has made a careful comparison of the structure, especially of the stems and foliage, of fifty-eight species of plants, taking specimens of each from the neighborhood of Paris and also from Carnoules, on the French Mediterranean coast. Working out the histology of these, with reference to the influence of the Mediterranean climate on structure, he has (among other differences) established the following regards in which the southern differ from the northern forms: Epidermis with larger and higher cells, with more regular contours and thicker walls; more intense lignification; increase of volume of wood and of bast; increase of thickness of leaves.

Generally speaking, these differences between Mediterranean and more northerly individuals of the same species are similar to those which distinguish the Mediterranean from more northerly species of the same genus. This is well shown by comparing, for instance, the Neapolitan species of *Smilax*, *Quercus*, *Rhamnus*, *Rubus*, *Rosa*, and *Viburnum* with those of northern Europe or the northern United States.

NAPLES, ITALY.

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[5] Influence du climat Méditerranéen. Ann. Sci. Nat. Bot. VIII. 1. —— 1895.

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